

***Possible Structural Linkage between
Neutrinos and Charged Leptons in
Neutrinos' Own Maximum Contact***

Kazuyoshi KITAZAWA

Risp Japan

(APS DPF 2021, 12-14 July)

Abstract

Possible structural linkage between neutrinos and charged leptons under neutrino mixing of being in neutrinos' own maximum contact is studied. Where it is provided that one neutrino (fermion) and neutrino-pair (boson) may interact. So it should have such a restrained condition that one neutrino makes a maximum contact number-6 (six) with other 6 neutrinos under 2D mixing. Then possible structural linkage between neutrinos and charged leptons will emerge vertically, and it seems common and recurrent in their three generations. There, the winding angles of series of the neutrino-pair, with which higher charged leptons (μ , τ) possibly build up, appear to fall almost on observed neutrino mixing angles of θ_{12} and θ_{23} , respectively.

BOSON-FERMION INTERACTION IN 2 DIMENSIONS

We shall at first assume an interaction between fermion (one neutrino) and bosons (three neutrino pairs), whose comprehensive theoretical treatment has been developed originally in nuclear physics.[1]

By putting this in mind for neutrino mixing, we could *intuitively* expect such a restriction that one neutrino should contact with six neutrinos to obey to the principle of maximum contact number-6 (six) in 2D.[2] Therefore we may think that the restrained particle of seven neutrinos, as second flavor, will be ν_{μ} , as shown in Fig.1. Also we may think that next proper restrained particle, as third flavor, will be ν_{τ} .

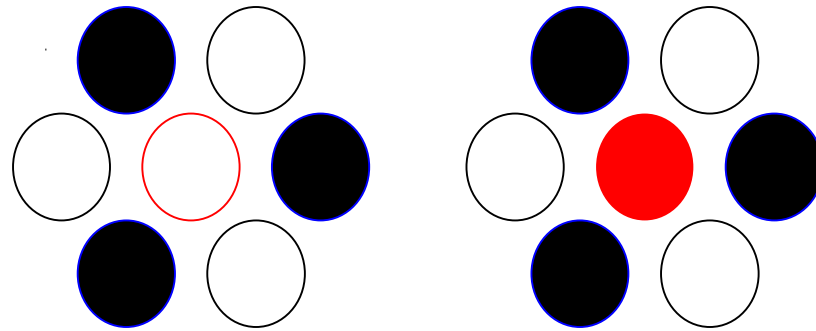


Fig.1 ν_μ (left) and $\text{anti-}\nu_\mu$ (right), where $\text{O}, \text{O}; \bullet, \bullet$ indicates ν_e and $\text{anti-}\nu_e$ respectively.

A reason why ν_μ or anti- ν_μ is ‘in a plane’, would be that the necessary number of neutrino (ν_e ; anti- ν_e), which satisfies a most stable state (a flavor state), is minimum with this geometry (plane). While in 1D the maximum contact-number is two (2), it is not able to form such contact ‘in a line’ by one neutrino pair (ν_e · anti- ν_e).

These processes are able to straightforwardly write down as follows;

$$\nu_e + \bar{\nu}_e \rightarrow (\nu_e \square \bar{\nu}_e) \quad (1)$$

$$3(\nu_e \square \bar{\nu}_e) + \nu_e \rightarrow \nu_e \square (\nu_e \square \bar{\nu}_e)^3 \equiv \nu_\mu \quad (2)$$

$$3(\nu_e \square \bar{\nu}_e) + \bar{\nu}_e \rightarrow \bar{\nu}_e \square (\nu_e \square \bar{\nu}_e)^3 \equiv \bar{\nu}_\mu \quad (3)$$

NEUTRINO OSCILLATION

So far we considered neutrino mixing from a viewpoint of the conditions of flavor eigenstates.

The oscillation scheme of neutrinos would therefore be expressed as shown in Fig.2.

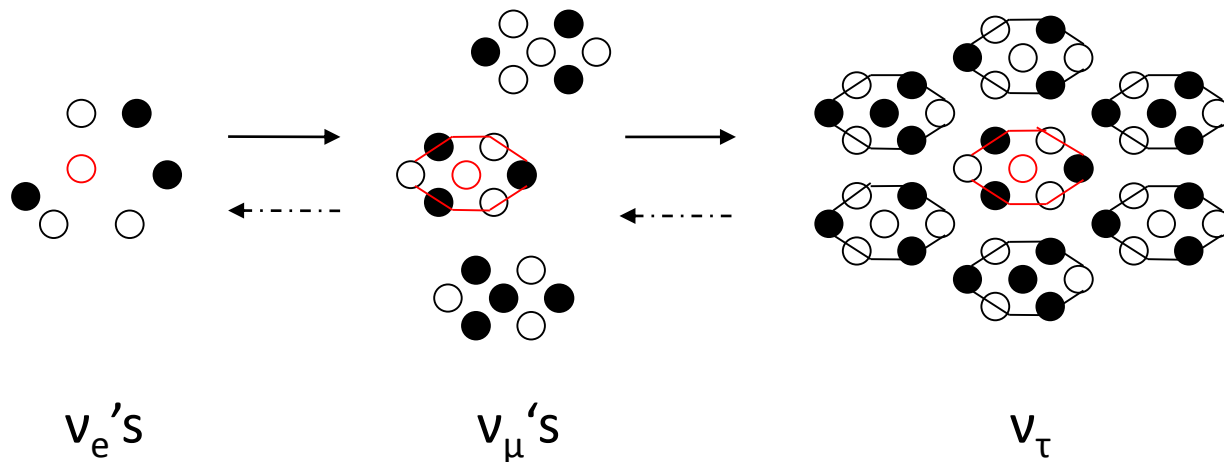


Fig.2 Oscillation scheme of ν_e 's, ν_μ 's and ν_τ

THE STRUCTURE OF CHARGED LEPTON

1. HYPOTHESIS

Charged lepton has three generations as well as neutrino. Though electron is stable, muon is unstable and tauon is more unstable. On the other hand, neutrinos over three generations are all stable. So one could suppose that lepton family has some structure and hierarchy. Since then we speculate that *the charged leptons are each made of their own neutrinos*.

2. BOSON-FERMION INTERACTION IN PSEUDO-ONE DIMENSION

Hereafter we study interactions between one neutrino (fermion) and a great deal of same neutrino-pairs (bosons), which will at last make each charged leptons. And we consider that they grow up in pseudo-1D. This situation is schematically shown in Fig.3.

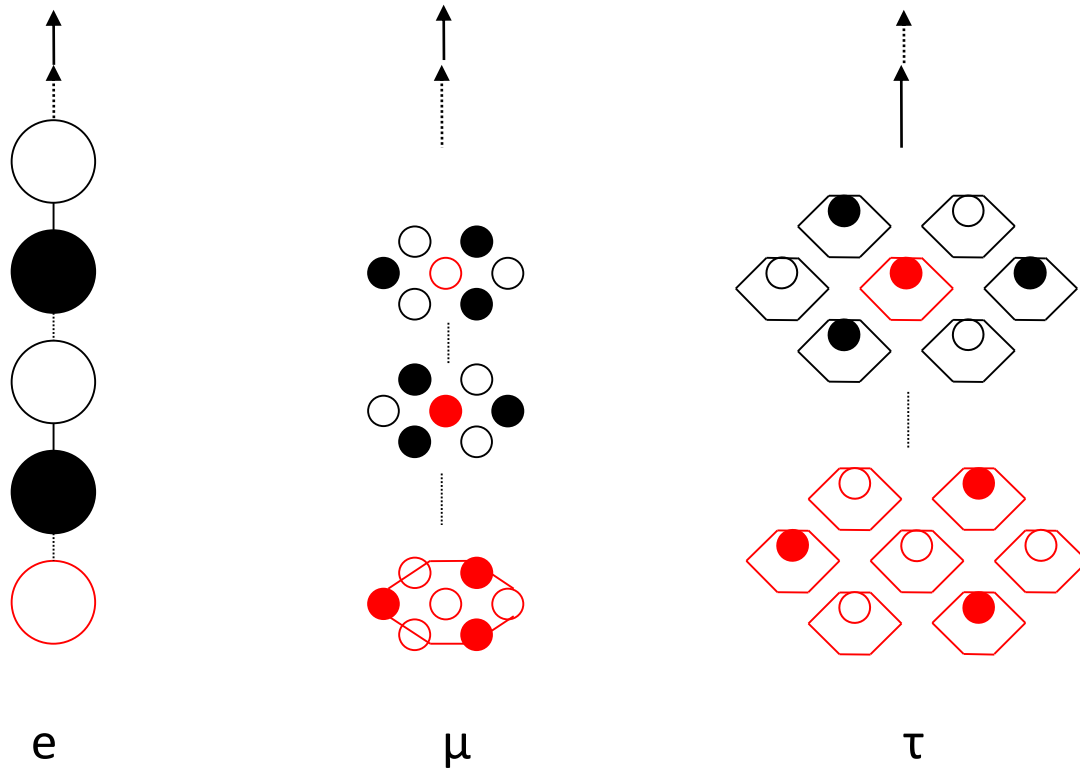


Fig.3 Growth into charged leptons (e , μ and τ), where \bigcirc, \bigcirc ; \bullet, \bullet denote ν_e and anti- ν_e , respectively.

REPRESENTATION OF DECAY MODES [3]

1. Muon

Muon has known main decay modes;

$$\mu^- \rightarrow e^- \bar{\nu}_e \nu_\mu, \text{ with } \mu^- \rightarrow e^- \bar{\nu}_e \nu_\mu \gamma; (e^- \bar{\nu}_e \nu_\mu e^+ e^-) \quad (1)$$

The structure of muon (cf. Fig.3) seems to be able to represent above decay mode. Because, eq.(1) could be qualitatively explained by the decays such that;

1) '1st bottom' := ν_μ

2) '2nd bottom center particle' := $\bar{\nu}_e$;

residual 'center particles' := e^-

3) Series of a lot of residual $\bigcirc - \bullet \dots, \bullet - \bigcirc \dots$ pairs
:= e^- , e^+ , γ

2. Tauon

Tauon has so many decay modes that we touch here only a few examples.

First of all, the above explanation about μ^- is also held for τ^- by replacing ν_μ , $\bar{\nu}_e$, e^- with ν_τ , $\bar{\nu}_\mu$, μ^- respectively in 1) and 2).

As to another main decay mode;

$$\tau^- \rightarrow e^- \bar{\nu}_e \nu_\tau, \quad \text{with} \quad \tau^- \rightarrow e^- \bar{\nu}_e \nu_\tau \gamma, \quad (2)$$

We may understand that it is the decay of;

‘1st bottom’:= ν_τ , plus

‘2nd bottom center particle’:= $\bar{\nu}_e$; residual ‘center particles’:= e^-

and series of a lot of residual ‘center vacant’ pairs:= γ

Moreover, the τ^- structure of Fig.3 is also able to explain miscellaneous decays (even for “decay with 5- or 7-charged particles”, especially, latter of which seems to imply appropriateness of the model).

THE PRECISE STRUCTURE OF CHARGED LEPTON

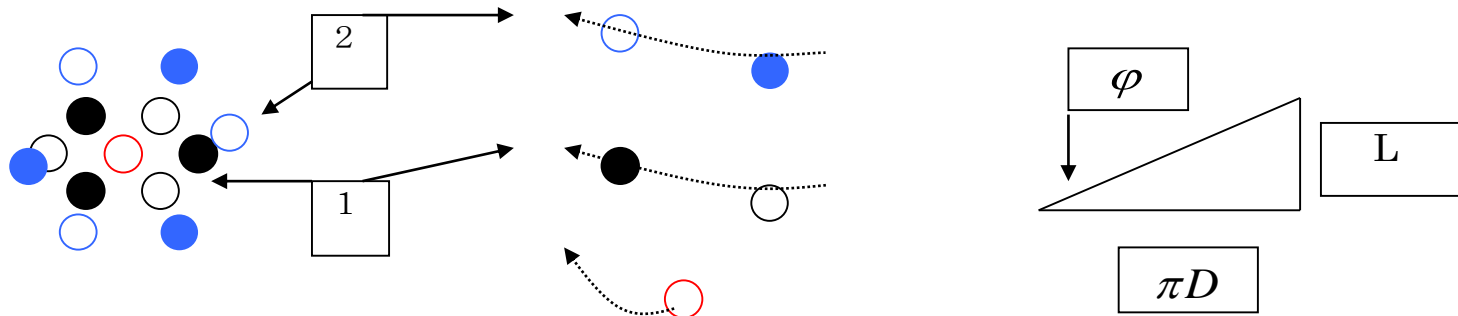


Fig.4 Growth to an electron as a pseudo-1D harmonic oscillator by winding ν_e -pairs chain ($\boxed{1} \rightarrow \boxed{2} \rightarrow \dots$) with lead angle φ .

The charged lepton has a same charge ($\mp e$). We now try to find its precise structure with this fact.

We shall at first consider charged lepton as a pseudo-1D harmonic oscillator with torsional (lead) angle φ as shown in Fig.4 (for electron). That is, after some growth to an electron, pseudo-1D ν_e -pair chain should have a torsion (let D: torsional diameter) and as a result very tiny but high frequency vibration to gain self-dynamical stability. Then we may write the generated charge by one ν_e -pair as:

$$|\Delta e| \propto \sigma_T = \frac{\text{Tension}}{\text{Area}_{(\text{chain})}} \quad (3)$$

And also, with vibrating term

$$|\Delta e| \equiv V(\sigma_T) \bullet F(t) \quad (4)$$

where,

$$\text{Tension} \propto \frac{\text{Curvature}(\rho)}{\text{Pitch}(P)} \quad (5)$$

$$\text{Area}_{(\text{chain})} = \frac{\pi}{4} d_{(ve)}^2 \quad (6)$$

Thus from eqs.(3) to (4),

$$\Delta e^{\mp} = \underbrace{\mp c' \left(\frac{\rho}{P} \right) \left(\frac{\pi}{4} d_{(ve)}^2 \right)}_{V(\sigma_T)} \times \underbrace{\frac{1}{2} (1 - \cos \Omega t)}_{F(t)} \quad (7)$$

Since

$$\rho \cong \frac{2}{D} \quad (8)$$

$$P = L = \pi D \tan \varphi \quad (9)$$

$$\text{then } \Delta e^{\mp} = \mp c' \frac{8}{\pi^2} \frac{1}{d_{(ve)}^2 D^2} \cot \varphi \times \sin^2 \left(\frac{1}{2} \Omega t \right) \quad (10)$$

Therefore we integrate eq.(10) for all $\left(\frac{N}{2}\right) - \nu_e$ pairs:

$$\begin{aligned} e^{\mp} &= \int^{\frac{N}{2}} \Delta e^{\mp} \\ &= \mp \beta \left\{ \frac{N_{\nu l} \cot \varphi_l}{d_{\nu l}^2 D_l^2} \right\} \sin^2 \left(\frac{1}{2} \Omega_l t \right), \quad \beta : \text{constant} \end{aligned} \quad (11)$$

After all, we get charge-representation equation for all lepton ($l = e^{\mp}, \mu^{\mp}, \tau^{\mp}$) by eq.(11). Since $\left\{ \right\}$ -term in the equation must be equal for all l , then

$$\frac{N_{\nu l} \cot \varphi_l}{d_{\nu l}^2 D_l^2} = \text{constant}. \quad (12)$$

The condition which satisfies eq.(12) is such that;

- (i) The 4th ν_l - pair: ●—○ is overlapped with the 1st ν_l - pair:

- at the 2nd winding, just at which looks next flavor.
(ii) Therefore, ‘winding length’ per one pitch is as $\pi D_l + \left(\frac{2i-1}{6}\right)\pi D_l$
where $i = 1, 2, 3, \dots$.

Under this condition, to refer configuration of Fig.4:

$$\begin{aligned}
\varphi_{(i,i+1)l} \equiv \varphi_l &= \cos^{-1} \left\{ \frac{\pi D_l}{\pi D_l + \left(\frac{2i-1}{6}\right)\pi D_l} \right\} \\
&= 31.0^\circ, \quad i=1 \\
&= 48.2^\circ, \quad i=2 \\
&= 56.9^\circ, \quad i=3
\end{aligned} \tag{13}$$

Here one can notice that *these values of $\varphi_{(12)e}$ and $\varphi_{(23)\mu}$ fall on both very near the observed values of neutrino mixing angles of θ_{12} and θ_{23} within their respective experimental tolerances.*

Subjects for the future

We should then quantize this first study in the next step. Followings are to be the additional subjects:

1. Regarding the value of $\sin^2\theta_{13}$, it is suggestive that $(1/7)^2 \approx 0.0204$ which is near the latest result of experiment. [3]
2. The mixing angle θ_{34} which would anyhow relate to $\varphi_{(34)\tau}$ ($= 56.9^\circ$) obtained above, has not been observed yet. [4]
3. The angular velocity of vibration ($\frac{1}{2}\Omega$) might have an intimate relation to Zitterbewegung in spin-1/2 particle of nonstationary states, which has a frequency of $2|E|/\hbar$ and then has a same order of wave length of Compton effect. [5]

ANNOTATION – RE: Neutrino oscillation Matrix

In this study, U_{li} is interpreted as a diagonal (identity) matrix, i.e.

$$M_{\nu l} = U_{li} M_{\nu i}, \quad U_{li} \equiv \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

That is,

$$\begin{bmatrix} m_{\nu e} \\ m_{\nu \mu} \\ m_{\nu \tau} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} m_{\nu 1} \\ m_{\nu 2} \\ m_{\nu 3} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} m_{\nu 1} \\ 7m_{\nu 1} \\ 49m_{\nu 1} \end{bmatrix} = \begin{bmatrix} 1 \\ 7 \\ 49 \end{bmatrix} m_{\nu 1}.$$

References

- [1] Iachello F and Arima A, 1987, “The Interacting Boson Model “, Cambridge University Press; and,
Iachello F and Van Isacker P, 1991, “The Interacting Boson-Fermion Model”, Cambridge University Press.
- [2] Conway J. H & Sloane N. J. A, 1999, “Sphere packings, Lattices and Groups”, 3rd ed., Grund. Math. Wiss. 290, Springer.
- [3] P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020) and 2021 update: and especially, ‘14. Neutrino Masses, Mixing, and Oscillations’ (by M.C. Gonzalez-Garcia et al.)
- [4] Böser et al. “Status of Light Sterile Neutrino Searches”, Progress in Particle and Nuclear Physics, vol.111, Mar 2020, 103736); arXiv:1906.01739 [hep-ex]
A. A. Aguilar-Arevalo et al. (MiniBooNE Collaboration), “Significant Excess of Electronlike Events in the MiniBooNE Short-Baseline Neutrino experiment”, Phys. Rev. Lett. 121, 221801–Published 26 Nov. 2018.
- [5] P.A.M.Dirac, “The Principles of Quantum Mechanics”, 4th ed., § . 69, (1958), Oxford;
A.O.Barut et al., Phys. Rev. D23, 2454 (1981); and
S.V.Bonsovskii et al., Phys. Part. Nucl. 28(1), Jan.-Feb. (1997)